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NOAA Program Plan 71-2

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Office of Plans and Programs

Plan To Improve Local Weather Forecasts

PENNSYLVANIA STATE UNIVERSITY
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Atmospheric
Division
ROCKVILLE, MD.

March 1971

NOAA PROGRAM PLANS

NOAA Program Plans are prepared by or under the auspices of the Office of Plans and Programs. They set out areas of major endeavors to be undertaken by NOAA. The plans constitute new initiatives or significant expansion and reconstruction of on-going programs. Normally, more than one NOAA Primary Organization Element is involved in implementation.

An integral part of each plan is the cost estimates of achieving the programmed goals by phases supported by brief justifications for subsequent budget requests. Where applicable, these plans provide the basis for Department of Commerce contributions to Federal Plans prepared by the Office of Federal Coordinator for Meteorological Services and Supporting Research in accordance with OMB Circular A-62.

NOAA Program Plans

NPP 71-1	Geophysical Monitoring for Climatic Change
NPP 71-2	Plan To Improve Local Weather Forecasts

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
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PLAN TO IMPROVE LOCAL WEATHER FORECASTS

Atmospheric Division

Rockville, Md.
March 1971

U. S. Depository Copy

FOREWORD

This National Oceanic and Atmospheric Administration Plan To Improve Local Weather Forecasts places particular emphasis on the 0- to 6-hour time period of the weather service to the general public and special user groups. As a result of the varied needs of these services, the meteorological problems within the present range of interest are many and diverse. Also involved are internal operating procedures and methods of working with the public.

The program identifies fundamental problems that must be solved if we are to improve the timeliness and accuracy of forecasts and warnings. The achievement of this objective is dependent on an experimental facility to be utilized for 1) development of equipment and technology, 2) translation of new knowledge and theory into operational forecast procedure, and 3) support to specialized data gathering projects.

The plan includes cost estimates of the many interrelated actions to be accomplished in five phases. These estimates may require adjustment as the results of R&D efforts are applied and the need for new equipment, procedures, and research become apparent.

Robert M. White, Administrator
National Oceanic and Atmospheric
Administration

PLAN TO IMPROVE LOCAL WEATHER FORECASTS

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PLAN TO IMPROVE LOCAL WEATHER FORECASTS

INTRODUCTION

The need for improving short-range forecasting has received increased attention in recent months. It is evident that a significant portion of user groups and the general public require more accurate and timely forecasts and warnings of events that occur in the time scale of 0 to 6 hours and the space scale of 100 miles or less (i.e.,mesoscale). A detailed study and evaluation of user requirements is given in Attachment A.

It is readily recognized that atmospheric processes or motions occur in a wide variety of scales in both time and space. These range from the smallest of atmospheric motions characterized by such phenomena as the "dust devil" or "whirlwind" to atmospheric motions that control the longer period weather over a hemisphere. These motion systems interact with each other, each to some extent affecting the future behavior of the other. The space scale occupied by each motion system is roughly proportional to the time scale. The smallest of these may last but a few minutes and produce havoc and destruction in their path over a few square miles in an urban area.

Fundamental problems that must be confronted if we are to improve the timeliness and accuracy of short-range forecasts and warnings can be summarized as follows:

a. We do not observe the initial state of the atmosphere on the scale we are attempting to forecast, nor do we know what data (e.g., frequency, spacing, and accuracy) are essential to the definition of this initial state.

b. We possess few prediction techniques that show significant skill over persistence in the 0- to 6-hour time frame.

c. All too often the forecaster is unable to detect adverse weather conditions or to warn the public in a timely fashion.

d. In rendering his service to the public, the forecaster does not have the tools he needs to make full use of the observed data and products that are available.

e. In mesoscale meteorology, there are shortages of sources of training and training material and too few trained NOAA personnel.

Attachment B describes present programs of the NOAA/National Weather Service (NWS) that provide weather information for the general public and for the special requirements of specified user groups.

I. OBJECTIVE

As a result of service demands by user groups, the meteorological problems within the present range of interest are many and diverse. Also involved are internal operating procedures and our ability to work with the public; therefore, the problem is not limited to scientific and technological improvement.

The objective of this plan is:

> TO IMPROVE THE PUBLIC WEATHER SERVICES WITH PARTICULAR EMPHASIS ON THE ZERO-TO SIX-HOUR TIME FRAME THROUGH MORE ACCURATE, TIMELY, AND SPECIFIC DESCRIPTIONS, PREDICTIONS, AND WARNINGS OF SIGNIFICANT WEATHER CONDITIONS AFFECTING THE ACTIVITIES OF THE GENERAL PUBLIC.

In the interest of clarification of the services of direct benefit to all user groups as well as the general public, the significant weather conditions are:

Precipitation occurrence, intensity, and type (e.g., hail, heavy snow, and freezing rain)
Lightning
Tornadoes
Dangerous or damaging surface winds
Blizzards
Frost
Air pollution
Storm surge, wave height, and high-tide conditions
Duststorms and sandstorms
Temperature extremes
Extent and amount of clouds
Visibility restrictions.

II. ACTIONS FOR IMPROVING THE SERVICE

A. Identification of Basic Problems

1. The report (OFCM 67-2) by an interagency task team to the Interdepartmental Committee for Applied Meteorological Research on the "Mesometeorological Research and Development Prospectus" in March 1967, noted that progress in the environmental sciences has been marked by an interplay between observations and theoretical studies. Improved descriptions have served to stimulate, guide, and evaluate theoretical studies. These studies in turn have provided better insight into further observational requirements. The report further noted that considerable progress has been achieved by this feedback between description and theory. Unfortunately, this progress has been primarily true of the synoptic scale. Advances have been slow on the mesoscale despite increasing awareness of the importance of this field. This is in large measure due to the diversity and the complexity of the problems involved and to the high cost of research required to achieve long-term gains.

2. Today, forecasts of mesometeorological phenomena are being made within what is essentially a synoptic scale framework. Synoptic-scale features, observations, and forecasts are translated into the mesoscale scale forecasts principally by kinematic modeling and statistical and analog techniques without a thorough knowledge of the interaction between the different scales. The accuracy of these forecasts depends on two interrelated aspects: (a) the ability to observe and forecast basic meteorological parameters which usually serve as input to these specialized techniques, and (b) the application of the

specialized techniques. Significant improvement in mesoscale forecasting will come only when we are able to observe adequately on the mesoscale and develop forecasting techniques applicable to this scale.

3. Table 1 offers possible approaches to solutions to the local forecast problems. It is the basis for actions proposed in the paragraphs that follow. A number of separate but parallel actions are necessary to improve our 0-to 6-hour forecasts. These include:

a. Activation of the Operation Field Test Facility for improvement of the 0-to 6-hour local forecast.

b. Actions that can be accomplished without field testing or further research and development.

c. Actions that are within the state of the art but which require field testing before they can be taken.

d. Research and development that is essential to improve the present state of the art.

e. Formal academic training in mesometeorology.

B. Activation of the Operational Field Test Facility

As a fundamental part of this plan, an Operational Field Test Facility (OFTF) would be established surrounding or adjacent to Oklahoma City, Okla., and/or St. Louis, Mo. The Facility would test and evaluate (and in some instances develop) weather observation and measurement systems, 0-to 6-hour local forecasting techniques, internal forecast office procedures, and services to user groups. The OFTF would also provide a test bed for the research and development set out in following parts of this plan. The activation and operation of the OFTF would be in two phases as summarized below. Attachment C has a more detailed discussion.

Phase 1 - In this phase, the experimental weather observation network specifically designed to provide data on the mesoscale would be established with emphasis on the detection/extrapolation of visible weather phenomena (e.g., clouds and precipitation plus other inferred phenomena detectable by radar and geostationary satellite imagery). The existing conventional synoptic scale network would be augmented, as necessary, to supplement observations of the "visible" weather by measurement of surface data and temperature and moisture profiles through the lower troposphere. Simultaneously, the weather office at the Facility would be established to manage and utilize the observation network as the initial step toward improving the 0-to 6-hour local forecast. As they become available, new equipment and analysis and prediction techniques would be tested for application to the mesoscale problems. A local computer capability would be provided for such things as local network control, meteorological watch, map plotting, upper air data reduction, and radar digitization.

Table 1.--An assessment of local forecast problems and possible solutions

Problem	Approach/Method	Main tools/Actions	Availability	Prospects
Significant phenomena and often not detected	Apply existing or near-term technology	1. Conventional networks	Now	Fair/Poor
		2. Geostationary satellites	Now - 5 years	Good
		3. Conventional radar	Now - 5 years	Good
		4. New remote sensors	2 - 5 years	Good
Initial state of the atmosphere is not well defined	Develop new technology	1. Doppler radar	5 - 10 years	Good
		2. Acoustic probing	5 - 10 years	Good
		3. Laser probing	5 - 10 years	Good
		4. Cheap auto station	3 - 5 years	Good
	Perform research on mesoscale models	1. Mesoscale network experiments	2 - 5 years	Good
	Perform research to improve early detection/recognition	2. Model research	3 years - Indef.	Fair
		3. Data interpretation	3 - 5 years	Fair/Good
Reaction time to significant phenomena is too long	Apply existing or near-term technology	1. Automated local operations	Now - 5 years	Good
		2. Expanded improved communications	Now - 5 years	Good
		3. Reassess forecast warning routine	1 - 2 years	Good
The public is not always notified in time	Develop new techniques for weather watch and public warning	1. Automated weather watch	2 - 5 years	Good
		2. Semiautomated dissemination	-2 - 5 years	Good
		3. User-oriented dissemination	2 - 5 years 2 - 5 years	Good Good
		4. Observation recall/replay	1 - 2 years	Good

Table 1.--An assessment of local forecast problems and possible solutions--Continued

Problem	Approach/Method	Main tools/Actions	Availability	Prospects
Tools to make optimum use of data and products available are inadequate	Apply existing technology to improve man's capability to focus on problem/area of concern	1. Automated local area plotting	2 - 3 years	Good
		2. Addition of local computer capability	1 - 2 years	Good
		3. Selective local displays	2 - 4 years	Good
	Develop new methods of local data handling and product access/display	1. Access to off-station banks and products	3 - 4 years	Good
		2. Enhanced local computation capability for local models	3 - 5 years	Fair/Good
		3. Higher resolution displays for satellites, etc.	2 - 4 years	Good
Centrally produced products not fully responsive to mesoscale area/time needs	Review spectrum of products for state-of-the-art improvements on synoptic and subsynoptic scale	1. Fine-mesh models	1 - 3 years	Fair
		2. Reduced time lag between data and prognoses	0 - 2 years	Good
		3. Increased time resolution	0 - 2 years	Good
		4. Direct use products	0 - 2 years	Fair
	Develop/improve products aimed at mesoscale	1. Boundary layer models	2 - 5 years	Fair
Mesoscale prediction techniques show little skill over persistence	Apply existing technology and formalize empirical relationships now in use	1. Local computation capability	1 - 2 years	Fair/Good
		2. Statistical relationships	1 - 2 years	Fair/Good
		3. Training	1 - 2 years	Good

Table 1.--An assessment of local forecast problems and possible solutions--Continued

Problem	Approach/Method	Main tools/Actions	Availability	Prospects
Mesoscale prediction techniques show little skill over persistence	Conduct research and development on mesoscale prediction techniques	1. Statistical relationships mesoscale-synoptic scale (perfect progs)	1 - 5 years	Good
		2. Mesoscale prediction models	Indefinite	Uncertain

Phase 2 - In this phase the Facility Weather Office (FWO) is expanded to include preparation of required weather service products under normal deadlines. The observing network would be expanded and increased use would be made of remote-sensing techniques. It is expected that an increasing flow of new equipment and analyses and prediction techniques would be available for testing in the networks and in the FWO during this phase.

C. Actions That Can be Accomplished Without Field Testing or Further Research and Development

Actions within this category can be taken now particularly if oriented to the basic objective of short-period local forecasts. They include:

1. Employ geostationary satellite imagery to utilize, in real-time, the cloud imagery from the Advanced Technology and the Geostationary Operational Environmental Satellites to enhance the weather watch capabilities of forecasting and to provide qualitative information on the growth, movement, and dissipation of smaller scale systems.

2. Review the frequency and types of products provided by the National Meteorological Center (NMC) to reduce the volume of data transmitted over existing circuits and replace less useful information with products directly applicable to the local forecasting problem.

3. Improve NMC guidance by an early run of the fine-mesh, limited-area model. Of great value would be series of products with better space/time detail made available several hours earlier than at present.

4. Expand watch/warning concept now applied to tornadoes, hurricanes, and winter storms to include all potentially hazardous weather conditions.

5. Expand direct telephone connections between Weather Service Forecast Offices (WSFO) and Weather Service Offices (WSO) to facilitate exchange of significant information.

6. Expand VHF/FM broadcasts to provide continuous broadcasts of weather forecasts and warnings for principal urban areas.

7. Expand use of the Civil Defense National Warning System to assure rapid positive contact with Civil Defense and law enforcement agencies immediately preceding and during severe weather and natural disasters.

8. Expand NOAA Weather Wire Service to make available to the mass media a single source for forecasts, warnings, and information services related to hazardous weather, as well as the more routine services.

D. Actions That Are Within the State of the Art but Which Require Field Testing Before Implementation

Actions within this category are within the state of the art but require some further development and field testing before they can be taken.

1. Automate a system of radar data digitization and processing to replace the manual interpretation and summarization that is now done at the local radar station and composited by the Radar Analysis and Development Unit at Kansas City. The principal uses of this product will be for regional and national depiction of significant radar information. An order of magnitude improvement in space/time resolution appears possible.

2. Provide radar/satellite mosaic composite pictures of the radar and satellite imagery for use in establishing the initial precipitation and cloud state on a quantified basis.

3. Video record radar and satellite images to provide the meteorologist with a playback of the radar scope images so that the smaller scale motion systems can be detected and studied in a meaningful manner.

4. Automate plotting of hourly surface data to produce local area surface charts by automated methods within a few minutes after data are received.

5. Improve local station procedures to eliminate nonprofessional tasks and improve the efficiency of the technical staff. Among these procedures are:

   a. Accelerated use of precut and prerecorded forecasts.
   b. Extensive review of forecasts and forecast contents.
   c. Review of assigned areas of forecasts and warning responsibility.

6. Develop low-cost automatic weather stations to provide observations in mesoscale network.

7. Remote-sensing equipment (Doppler radar, acoustical and optical sounders, and low-level rawinsondes) to provide horizontal and vertical profiles on the mesoscale.

8. Cathode ray tube equipment to ease the office workload.

E. Research and Development Required to Improve the Present State of the Art

The material in this section has been drawn from OFCM Report 67-2, Mesometeorological Research and Development Prospectus. The OFCM Report recommends four research projects that bear directly on the objectives of this plan:

1. Profiles in the Boundary Layer - Forecasting profiles of wind,

temperature, and moisture in the boundary layer appears to provide a key to the solution of many mesoscale problems. Research to increase that capability is one of the initial parts of the proposed program. Better knowledge of the structure and variability of the small-scale motion systems is required. The design of the boundary layer project must include determination of the power spectrum of the atmospheric variables within the mesoscale. It must also provide for the time-and-space correlation and regression statistics of profile elements as a function of location, time of day, month or season, and various synoptic and smaller scale features.

2. Clouds and Precipitation - What is needed is an improved capability to forecast clouds and precipitation phenomena with improved time-and-space resolutions. Essential to this capability is a better understanding of the mesoscale structure, the time-and-space variability of these phenomena, their relationships to the several meteorological scales and to geographic features. On the small scale, which includes forecasts of up to 2 hours, the cloud and precipitation problem might be directly incorporated into the boundary layer studies.

3. Air Resources - For the protection and preservation of our air resources, a better understanding is required of air pollution meteorology and those atmospheric processes involved in the transport, diffusion, and dilution of airborne materials. Field experiments and theoretical formulation of the diffusion of airborne materials over short distances on the order of a few hundred meters have been carried on for more than 30 years. More needs to be learned about atmospheric transport and diffusion over long distances up to 100 kilometers or more. Descriptions and forecasts of transport and diffusion over distances greater than a mile are now based largely on empirical extrapolation because experimental studies on the meso- or smaller scales are both fragmentary and inconclusive.

4. Severe Convective Storms - During the past decade, a number of diagnostic computer programs processing certain severe local storm parameters have been incorporated into the forecast routine. However, the present state of the art requires that the forecaster, to a large extent, subjectively assess the relative importance of various indicators to arrive at a forecast decision. Empirical rules and diagnostic techniques do not necessarily lend themselves to forecast decisions. The improvement of severe local storm forecasts should be approached by obtaining more information on the space-and-time distribution of the basic meteorological parameters both within and around the storms. The increased knowledge of storm morphology and dynamics could lead to a numerical modeling and effective numerical diagnostic and prediction programs. The studies required will demand a great effort and many years before they can be expected to come to full fruition. Therefore, a significant amount of the effort devoted to such a project should be aimed at near-term gains in the capability to forecast the severe storms. Also, our ability to locate and monitor individual storms must be enhanced. Once these storms have developed, radar and satellite imagery provide the forecaster with the best observational tools. Here, however, one must surmount a formidable problem that arises from the rapid decay of the usefulness of the information pertaining to small-scale motion systems. In order for the forecaster to keep up to date on these rapidly developing, fast-moving systems he must perform three-dimensional

analyses at frequent intervals with minimum delay. A data acquisition system capable of providing the necessary temporal and spacial density needs to be implemented.

F. Training and Manpower

1. Present curricula of the academic community place little emphasis upon meteorological training designed to produce an adequate forecast in the 0-to 6-hour time frame. Most of what is known and utilized today has been developed and learned in the school of "hard knocks." That is to say that the experienced forecaster over a period of time and with little formal training in mesoscale forecasting has learned to produce mesoscale forecasts.

2. By the mid-1970's, most forecast offices are expected to have access to near-continuous satellite imagery and considerably improved radar displays and mosaics. This access will permit the forecaster to study time-lapse movies of cloud changes in his area of interest. However, proper interpretations of such imagery requires adequate knowledge of the dynamic and thermodynamic processes involved in the varying scales of motion. Although some success will no doubt be enjoyed initially by using existing experience, training must be provided to assure that those persons assigned the responsibility for interpreting the imagery are well grounded in mesometeorology.

3. Superimposed upon the problems of utilizing new technology is the problem of maintaining an adequately trained professional work force. In this connection, a 1967 study indicated that at that time about 50 percent of the meteorologists in the ESSA Weather Bureau were in the 43 to 55 age bracket. Consequently, we face significant future increases in losses of this work force due to retirement, death, and other causes. The timing and magnitude of the loss rate must be considered in future employment, recruitment, and career development programs.

4. In the 1967 study, the answer to the question "How many meteorologists will retire when they reach 55 years of age with 30 years' service (basic eligibility)?" suggests that the meteorologist retirements and other losses will increase at a relatively uniform rate and reach a maximum of 72 per year in 1978. The recent retirement law that permits the employee to compute his retirement annuity on the basis of his highest 3 years of income would seem to result in this peak being reached as much as 2 years earlier. In either case, this represents an increase of about 200 percent over a 10- to 12-year period. It seems prudent to plan on the peak retirements occurring as early as 1975 to 1976, since there are a number of reasons to consider the 1967 forecast as conservative.

5. The foregoing analysis of retirement losses coupled with the sizeable loss of young meteorologists each year requires that we give more attention to the training problem. These considerations have resulted in a "stepped-up" rate of forecaster refresher training and the establishment of the National Weather Service Technical Training Center at Kansas City. The present training activities are not likely to produce an adequate number of meteorologists with competence in the analysis and prediction of local weather events related to the small-scale motion systems.

6. As a minimum at least one specialist trained in mesometeorology should be available as soon as possible in each WSFO. In addition NOAA needs to stimulate the academic community to add courses on mesometeorology for undergraduates as well as for NOAA personnel in postgraduate training.

III. ALLOCATION OF RESOURCES

A comprehensive cost analysis for this plan would have limited reliability past the first two or three years. This limitation results from the necessity to rely on the contributions from the scientific efforts progressing in parallel with the operational field test program for increased knowledge of small-scale phenomena, prediction models, and techniques and equipment for applying satellite and radar data and imagery. Attachment D has a summary of the estimated costs to establish and maintain the Operational Field Test Facility.

ATTACHMENT A

User Requirements and Service Values

1. It is well to clearly understand the nature of the need for improving short-range forecasting when considering how much resources are to be committed to this effort. One of the fundamental problems facing NOAA arises from uncertainties in providing answers to questions concerning the relationship between the expenditure of effort and the user's needs for services. In continuing attempts to assess the needs, the National Weather Service prepared a listing of user groups that could benefit by improved prediction and description of the weather.

2. These user groups (table A-1) are analyzed in a report to the Interdepartmental Committee on Atmospheric Sciences (ICAS) entitled, The National Research Effort on Improved Weather Description and Prediction for Social and Economic Purposes. The report presents information useful in evaluating services rendered the general public. The ICAS space/time weather parameter matrix is defined below:

Space

1 = 1 mile	Microscale
2 = 1-100 miles	Mesoscale
3 = 100-1,000 miles	Macroscale (synoptic)
4 = 1,000-4,000 miles	Continental (planetary wave) scale
5 = 4,000 miles	Hemispheric-global scale

Time

1 = 0-1 hour
2 = 1-6 hours
3 = 6-24 hours
4 = 24-72 hours
5 = 72 hours - 1 month

3. The matrix in figure A-1 was developed from data used in the original ICAS Study. It is based upon the needs of the user groups given in table 1. The parameters considered are: wind, temperature, precipitation, clouds, and lightning. The numbers given in the center of the space/time classes are the percentages of total service demands by all space/time categories in which the five weather parameters seem important. The central isopleth identifies the space/time classes where the greatest percentage of user demands were found. Care should be exercised in interpreting figure A-1. The lack of substantial need on the large scales is not surprising and should not be interpreted as a lack of need for service and R&D programs relating to global atmospheric processes as these processes directly influence weather on all scales.

4. Since the matrix Figure A-1 gives equal weighting to each of the user groups, it does not necessarily represent the varying importance of weather services to each of the groups. For example, when data pertaining to only the general public user classes are examined, as in figure A-2, the

significance of the 0-to 6-hour forecast to the general public is sharply highlighted; more than 45 percent of the service demand falls within the first two space/time classes. From such an analysis, it is apparent that assigning additional weight to the public service demand would orient the overall user group demand even further toward the smaller space/time classes.

5. Since the initial matrix gives equal weighting to each of the 18 user groups, it may not fairly represent the relative sensitivity and hence the varying importance of weather services to each group.

The matrix in figure A-3 shows service demand distribution resulting from user class weighting. In considering the importance of the user groups, all those under Social and Public Welfare Classes, except General Public, were eliminated because of their ill-defined requirements for weather service. The remaining 14 classes used to derive the matrix in figure A-3 were weighted according to the criticality of the weather service to the user and the degree to which this service is considered to be a Federal responsibility. The following weighting resulted:

1.	General public	x10
2.	Land transportation	x 1
3.	Air transportation	x 3
4.	Water transportation	x 2
5.	Construction	x 1
6.	Water supply and control	x 1
7.	Energy production and distribution	x 1
8.	Merchandising	x 1
9.	Recreation	x 1
10.	Manufacturing	x 1
11.	Fishing	x 2
12.	Agriculture	x 3
13.	Forestry	x 1
14.	Communications	x 1

6. The minor effect user class weightings have on the final distribution of total service demand is easily observed by comparing figures A-1 and A-3. Even when alternative weightings were tested, the distribution of the data showed the greatest service demand to be invariably in the lower space/time classes.

7. In the weighted service demand matrix (fig. A-3), 36 percent of the total requirement falls within the first space-scale column -- less than 1 mile. This space scale encompasses weather service demands related to meteorological phenomena which often cannot be defined by our current services. This is primarily because of the lack of resources to utilize to the fullest the existing technologies. Consequently, entries in the "less than 1 mile" space class represent service requirements that are not now generally being met.

In summary, most user groups and the general public in particular require accurate and timely forecasts and warnings of events that occur on small space-and-time scales. More than 45 percent of the general public's needs for weather services relate to time scales of 0 to 6 hours and space scales of 100 miles or less.

Table A-1.--Weather information user groups

Social and Public Welfare Classes

1. General public

Includes needs of housewives, commuters, school children, and vacationers, that is, all general public activities and planning that may be affected by weather information.

2. General science

Includes all fundamental scientific studies and those experiments by Government and private organizations affected by or concerned with meteorological information.

3. Health and safety

Includes essentially all functions of the Public Health Service, AEC, FAA, and Department of Defense having to do with direct health and safety applications such as the understanding or amelioriation of air pollution, or the choice of favorable climate, location, or site design to minimize the adverse effect of the environmental factor on human health and safety.

4. General welfare

Includes all functions of the Departments of Health, Education, and Welfare, and Interior (National Parks) concerned with the preservation or improvement of the environment for its social, esthetic, or recreational value, where meteorological factors are involved.

5. Resources utilization

Includes all functions of the Departments of Agriculture, Interior, and Commerce which contribute to broad-scale use and conservation of natural resources for economic purposes. This class also includes the effects of such meteorological factors as the economics of industrial placement and planning of transportation systems.

Commercial and Industrial Classes

6. Land transportation

Includes essentially the trucking, bus, and railroad industries.

7. Air transportation

Includes Government, commercial, and private aviation interests.

Table A-1.--Weather information user groups--Continued

8. Water transportation

Includes both inland water (i.e.,Great Lakes, navigable rivers) and ocean-going transportation.

9. Construction

Includes all organizations involved in the planning, design,and actual building of structures and most civil engineering projects such as roads and bridges.

10. Water supply and control

Includes all commercial and public utilities interested in water availability, storage, use, and conservation; includes essentially all hydrological applications.

11. Energy production and distribution (light, heat, and power)

Includes commercial and public utilities concerned with the production and transmission or distribution of these commodities.

12. Merchandising

Includes all organizations concerned with the packaging, advertising, display, and sale of goods.

13. Recreation

Includes operators of, and commercial interests in, recreational activities facilities, e.g., boating, skiing, and sports events, not including the participating or observing public.

14. Manufacturing

All organizations involved in the production of goods or equipment.

15. Fishing

Includes all commercial fishing on the high seas, inland waters, coasts, and bays as well as the shipboard processing, storage, and packaging of the product.

16. Agriculture

Includes the farmer, rancher, horticulturist, fruit grower, and truck and poultry farmers-- all whose business derives from or is dependent upon the soil.

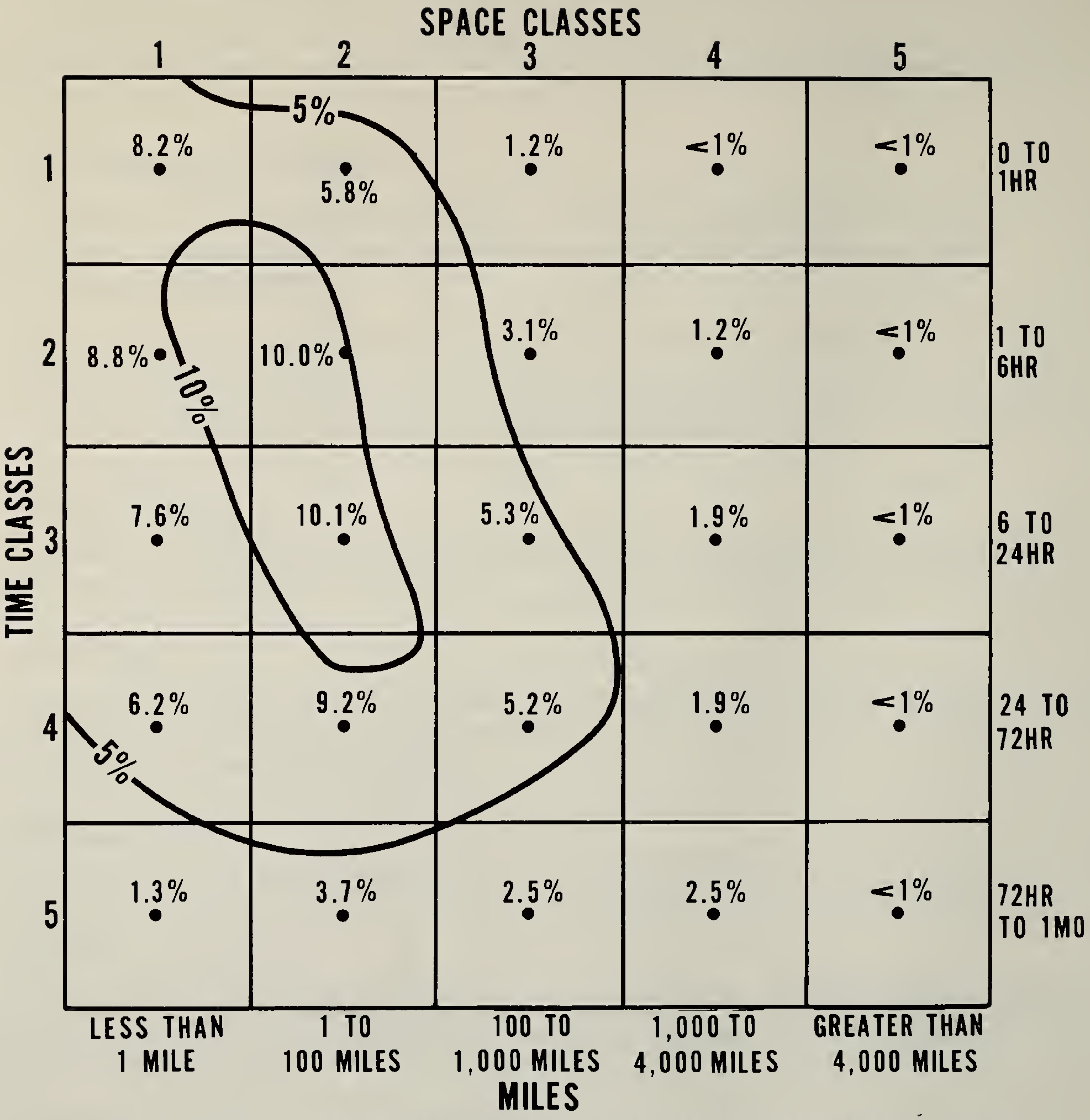
17. Forestry

Includes all activities concerned with the utilization of forest products (i.e., lumbering) and reforestation for commercial purposes.

Table A-1.--Weather information user groups--Continued

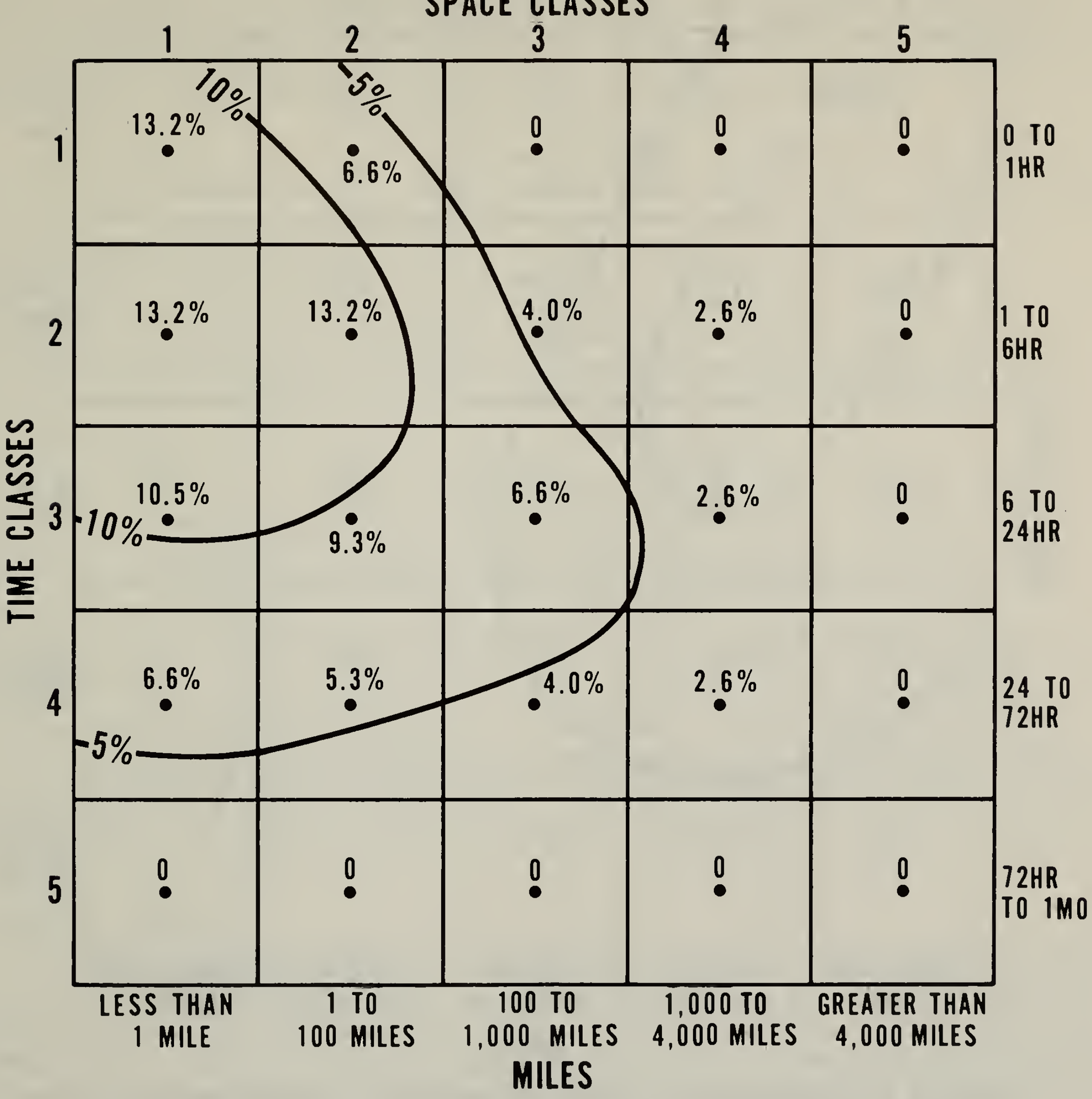
18. Communications

All organizations concerned with the efficient coordination or transmission of signals comprising the various means of communication (i.e., electromagnetic, visible light, lasers, or sound) including telephone, radio, television, communications satellites, and microwave relay systems.



	1	2	3	4	5	
1	8.2%	5.8%	1.2%	<1%	<1%	0 TO 1HR
2	8.8%	10.0%	3.1%	1.2%	<1%	1 TO 6HR
3	7.6%	10.1%	5.3%	1.9%	<1%	6 TO 24HR
4	6.2%	9.2%	5.2%	1.9%	<1%	24 TO 72HR
5	1.3%	3.7%	2.5%	2.5%	<1%	72HR TO 1MO
	LESS THAN 1 MILE	1 TO 100 MILES	100 TO 1,000 MILES	1,000 TO 4,000 MILES	GREATER THAN 4,000 MILES	

Figure A-1.—Initial service demand matrix (18 user classes equally weighted)



TIME CLASSES	SPACE CLASS 1 LESS THAN 1 MILE	2 1 TO 100 MILES	3 100 TO 1,000 MILES	4 1,000 TO 4,000 MILES	5 GREATER THAN 4,000 MILES	
1	13.2%	6.6%	0	0	0	0 TO 1HR
2	13.2%	13.2%	4.0%	2.6%	0	1 TO 6HR
3	10.5%	9.3%	6.6%	2.6%	0	6 TO 24HR
4	6.6%	5.3%	4.0%	2.6%	0	24 TO 72HR
5	0	0	0	0	0	72HR TO 1MO

Figure A-2.—Single user class service demand matrix (general public)

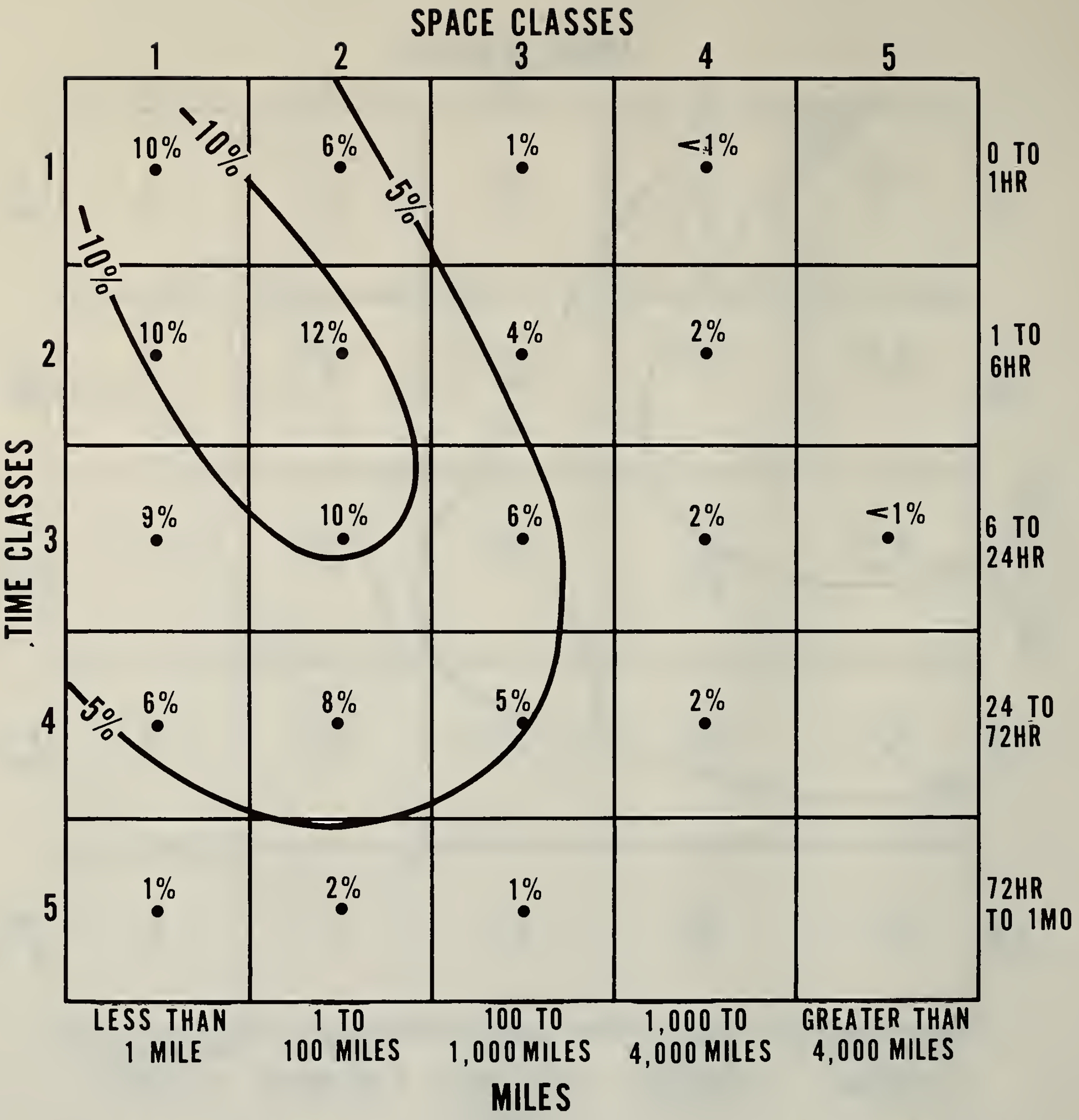


Figure A-3.—Representative service demand matrix (14 weighted user classes)

ATTACHMENT B

Present Service Program

A. Analysis and Forecasts

1. Services of the NOAA/National Weather Service (NWS) have been designed to generate weather information in support of the general requirements of the public and the special requirements of specified user segments. The recent NWS reorganization realined field components to provide improved weather service to its users. Figure B-1 gives the new structure.

2. A significant objective of the new forecast system is to have each Weather Service Forecast Office (WSFO) sufficiently staffed with meteorologists to maintain a continuous, around-the-clock, meteorological watch over its area of responsibility, and to monitor all forecasts and warnings issued by Weather Service Offices (WSO) within that area. Thus, when the forecast reorganization is fully implemented, the entire United States will be covered at all times by a meteorological watch/monitoring operation by professional meteorologists. The number of WSFOs assures a reasonably small area of forecast responsibility; an essential first step in any program to improve short-period forecasting of small-scale phenomena.

3. During the past decade, considerable success has been achieved in the utilization of computer technology in centralized weather processing methods applicable to the longer time periods and larger space scales. This utilization has not been the case in local, short-period forecasting. It has been increasingly evident that the role of a man in the system has to be reemphasized at least during the foreseeable future if we are to successfuly attack the problem of short-period forecasts and warnings of local weather conditions. Man's unique capabilities to make decisions based on experience and often conflicting evidence have to be utilized in this area where models and computer applications are inadequate today and little real progress can be predicted for a number of years. This fact resulted in the policy decision to staff WSFOs with sufficient meteorologists to maintain the meteorological watch/monitoring function for their area of responsibility.

B. National Centers

1. The National Meteorological Center (NMC) principal prognostic products are predictions of meteorological conditions expected to exist in time periods generally in excess of 12 hours in the future. These predictions involve considerations of motion systems ranging from synoptic to hemispheric scales. NMC products are currently of limited assistance to the mesoscale forecast; however, significant assistance with the mesoscale problem can be expected from the NMC in the future. The fine-mesh primitive equation model is expected to assist in the short-period local forecasting problems. NMC expects to improve the timeliness of its products by issuing the fine-mesh model analyses and predictions much earlier than present products are now available.

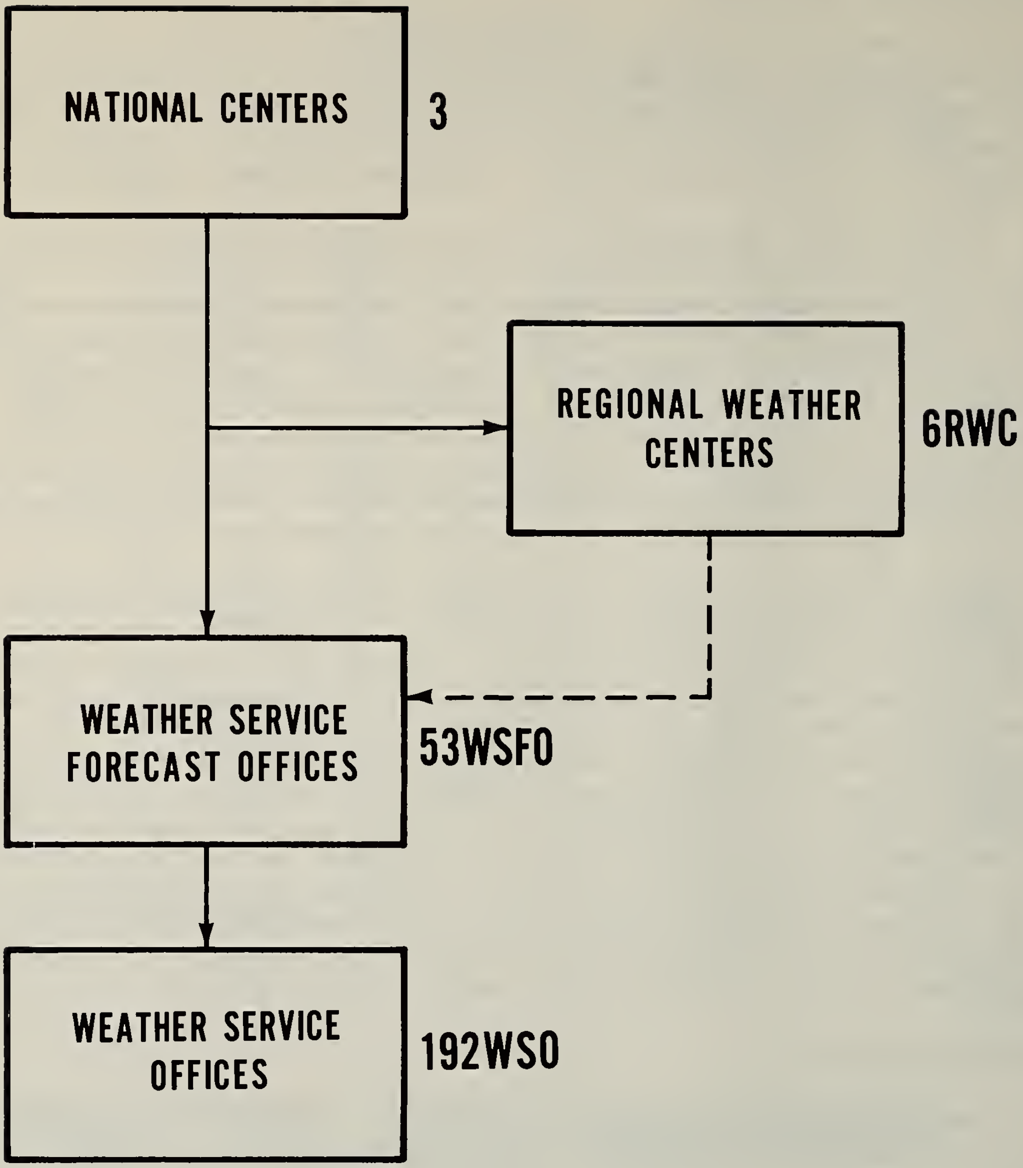


Figure B-1.—The new forecast system

2. The National Severe Storms Forecast Center (NSSFC) and the National Hurricane Center (NHC) are the main sources of specific forecast information regarding the local severe storms and hurricanes, respectively.

C. Regional Weather Centers (RWC)

One RWC is assigned to each of the six NWS Regions covering a specified geographic area. The RWC will be responsible for coordinating the warnings within its area and with contiguous regions. It will also perform the functions of product monitoring, unscheduled forecast interpretation, and quality control for all NWS operations within its area. A RWC may also prepare aviation, area, and various watch or alert products when it is more expeditious or effective to do so at one location rather than at several forecast offices.

D. Weather Service Forecast Offices (WSFO)

WSFOs are located roughly one per State and are designed to emphasize forecasts and warnings of weather events expected to occur in periods less than 24 hours in advance. They utilize guidance materials provided by the National Centers as the base for the specific forecasts and warnings of expected weather conditions. Supplementary information not already incorporated in the National Centers' products are available in some cases. With these supplementary data and an adequate processing capability, it is possible for WSFOs and WSOs to improve the service products relating to space/time scales smaller than those normally depicted by National Center products. Generally, the current practice is to emphasize specific forecasts and warnings and events expected to occur in the period of 6 to 24 hours after the time of the original new information.

E. Weather Service Offices (WSO)

The principal function of the WSO is to provide short-period forecasts of local weather events and issue timely warnings as required. The WSO uses the guidance and product outputs of the National Centers and its supporting WSFO. Some additional local information may be available to enable the WSO to be more specific about events expected within less than 6 hours within a radius of about 25 miles from the office.

F. Observations

The scale of the input data required for accurate forecasts and warnings is roughly equivalent to the scale of the event involved. To forecast and warn of small-scale atmospheric motions requires the availability of mesoscale data. It is true that some logical deductions can be made concerning expected weather events associated with adjoining scales of motion from input data designed to predict the weather associated with a particular scale of motion. In fact, this prediction is being done now out of necessity, i.e., forecasting mesoscale phenomena using macroscale data. The conventional networks (surface and upper air) do not have the space/time resolution required for mesoscale forecasting. Radar, where it is available, provides some of the additional information needed. Finer scale networks of conventional data and new developments such as geostationary satellites and remote sensing are essential to significant progress in mesoscale forecasting.

G. Communications

1. The efficiency of the weather service system is highly dependent upon the communications systems supporting it. The basic communications system comprises a group of high-volume, complex communications links maintained for the collection of observational data from global sources, the distribution of these data to appropriate processing centers, and the dissemination of meteorological analysis, forecasts, and warnings to millions of users. The time interval from observations through central processing to delivery of the required product must be minimized to provide users with timely and useful information. The use of specialized circuits, high-speed equipment, and automated procedures contributes to this objective.

2. These links are used to deliver the raw data to the central processing locations, i.e., NMC, NHC, NSSFC, and the forecasting offices. The largest of these are the services A and C operated by the Federal Aviation Administration in accordance with agreements between the Department of Commerce and the Department of Transportation. NOAA-operated and-controlled circuits transport highly specialized data and disseminate environmental information to the public.

3. Teletypewriter, telephone, telephone-answering devices, VHF broadcasts, and the facilities of radio, television, and news media are all used to insure rapid and timely dissemination of weather forecasts and warnings to our users.

4. The NOAA Weather Wire Service (NWWS) is the statewide teletype warning network to expedite the delivery of consumer-oriented warnings and forecasts to mass news media and other public and private interests in all of 19 States and portions of nine others. Participating radio and television stations receive regular weather forecasts and other information for immediate broadcasts to the public. NOAA pays for the backbone circuit, and the users pay the cost of the local connections and equipment needed to receive this information. The system provides the most effective and expeditious means of delivering warnings to a large segment of the population. It also provides a continuously available channel to distribute weather information to marine, water resources, agriculture, and forestry interests. One WSO in each State served by the NWWS is designated as a control center and as such is staffed with the data editors for handling the communications workload. Present plans and budget requests, if implemented, will eventually extend the NWWS thoughout the United States.

5. The Radar Report and Warning Coordination (RAWARC) system is an intra-NWS network which collects and distributes radar, severe weather, hydrological reports and warnings, and general weather information not available on the scheduled national circuits. The system consists of five circuits connecting 185 WSOs and WSFOs. It is used for direct coordination between forecast offices and is the only system immediately available for intra-NWS dissemination of the unscheduled traffic load resulting from severe weather situations.

6. The Hurricane "Hot Line" is a supplement to the RAWARC during the hurricane season. It is a dedicated telephone system established between NHC in Miami and NMC in Suitland for coordinating information on the location, intensity, and expected movement of hurricanes. The NWS Hurricane Forecast Offices at New Orleans, Washington, San Juan, Boston, the National Environmental Satellite Service (NESS), and the NWS Control Center in Silver Spring are also served by this system.

7. The National Facsimile System distributes basic charts depicting selected observational data, analyses, and forecasts required by the weather offices of NOAA, other Government agencies, airlines, and other interested public and private subscribers. The basic facsimile circuits and the equipment in NOAA offices are funded by NOAA while other agencies and/or individuals pay for their individual connections and equipment. The transmissions originate in NMC and NESS in Suitland, and in NSSFC in Kansas City.

8. The Forecast Office Facsimile System distributes to WFSOs the guidance material prepared by NMC. The system also provides for the distribution of cloud imagery from NOAA satellites.

9. The Aviation Meteorological Facsimile System distributes NMC and NESC products to main meteorological offices of NWS and to military and commercial users.

10. Automatic telephone-answering service to handle incoming calls for local weather forecast information is operational in 19 cities. This service is a cooperative effort between NOAA and the telephone companies which disseminate them to the public at no cost to NOAA. The number of calls made to the 19 large automatic telephone-answering repeaters in 1969 was over 300 million. In addition to the automatic telephone-answering services maintained by the telephone companies, NOAA has augmented its ability to respond to telephone requests by installing rented automatic answering equipment. By the end of FY 1970, multiline automatic answering services were available in 29 cities. Eventually this service will be extended to all major cities throughout the United States.

11. Continuous VHF radio weather transmission facilities operated by NWS have been established in 29 cities. This service on 162.55 MHz provides continuous radio broadcast of weather forecast and warnings and other pertinent weather information direct from the WSOs and WSFOs to the public and to disaster relief agencies. Through the use of a tone-alert device, specially equipped radio receivers can be activated by the NOAA transmitter to provide a positive and immediate notice of warning. Eventually this service will be established at a total of 180 locations in the United States.

H. System Response Time

1. The present system (acquisition, processing, and dissemination) has a strong impact upon the time required to warn the public. It now takes far too long after a decision is made to "warn" before a significant percentage of the concerned population is aware of the warning. The decision to warn can only be made after observations or reports are transmitted to the

WSO and analyzed. The present system response time is wholly inadequate for small-scale, short-lived phenomena.

2. Some NMC products do not become available to the user until as much as 9 hours after observation time. WSFOs require a processing time of about an hour to prepare routine forecasts following receipt of basic products and guidance from NMC.

3. In many developing "short-fuse" warning situations, questions concerning the behavior or the expected behavior of the storms can only be answered by looking at what is happening over an area a few tens of miles in horizontal extent and a few miles in the vertical. The lack of mesoscale data and the time required to acquire, process, and disseminate information that is available are the current constraints on local forecasting today.

ATTACHMENT C

Operational Field Test Program

A. General Concept

1. The basic ingredients for the improvement of local weather forecasts are so interdependent that their development and integrated application can best be done at a unique facility dedicated to this program. Significant in the selection of the location of this facility is the exposure to a wide variety of weather systems (including fast-developing and rapid-moving small-scale severe storms), the influence of a large urban complex, the service to a diverse and large number of user groups, and the immediate availability of a competent academic and scientific capability.

2. To satisfy these requirements, an Operational Field Test Facility (OFTF) will be established surrounding or adjacent to Oklahoma City, Okla., or St. Louis, Mo. (Choice of location to be made on the basis of detailed study to determine the best alternatives.) The Facility would manage its own specially designed observation network, develop and apply guidance for 0-to 6-hour local forecasting, and devise improved internal forecast office operational procedures and service systems to users. The OFTF must also be capable of supporting other specialized data gathering projects and serving as a test bed for research and development experiments and programs. The two main components of the OFTF will be the Facility Weather Office (FWO) and the experimental weather observation network. The following paragraphs discuss these two components, how they work together, and the phasing of the program.

B. The Facility Weather Office (FWO)

1. The FWO will be established as the management element to OFTF. It will develop and test in "real-time" new analyses and forecast techniques for the mesoscale, observation procedures and equipment, and new internal weather service office procedures. It will operate and use the experimental observation network. The network will be designed to permit flexibility as needed to support evaluation of the 0-to 6-hour forecast improvement effort.

2. Initially, data from the observation network will be telemetered to an on-station computer where it may be necessary to manually plot and analyze the data. As experience accumulates, the most effective man/machine mix for data processing, plotting, and display for the meteorologist will be ascertained. The ultimate goal is to achieve a near-continuous automated display of mesoscale weather, cloud, and wind systems for the use by the forecaster. It is expected that an increasing flow of new equipment and analyses and prediction techniques will be available for testing at the FWO as the field program progresses.

3. The following are examples of activities which can be conducted:

a. Alternative staffing arrangements can be tested and trade-offs developed between additional personnel and automation.

b. The use of satellite Vertical Temperature Profile Radiometer

(VTPR) data for mesoscale analysis would be developed.

c. Tests of techniques for automation of message composing would also be made.

d. With access to off-station data banks and computer products, techniques would be tested for selective retrieval and automated display of data needed by the forecaster; for example, satellite and radar data, low-level soundings, winds aloft, and surface observations.

e. A statistical data bank for use in development of statistical prediction techniques would be established.

f. A specialized effort to develop techniques suitable for prediction of atmospheric turbulence and diffusion would be made in connection with requirements of air pollution activities.

C. The Experimental Observation Network

1. A dense network of observing points would be established with emphasis on the measurement of visible weather utilizing human observers and geostationary satellites, plus WSR-57 radar coverage. The existing conventional network would be augmented as necessary to supplement the visible weather observations by measurement of the basic meteorological elements of surface temperature, pressure, moisture, and wind and their profiles through the lower troposphere.

2. The required density of the surface observation network will depend on the dimension of the mesoscale system to be detected, defined, and predicted. In general, the systems are a few tens of miles in horizontal extent and exist for a few hours. It is currently estimated that to detect 100 percent of these systems developing and/or passing through a given local forecasting area with an optimum subjective description of the system, a spacing between observation points of 30 nautical miles will be needed. Further, all parameters should be observed continuously and regularly scheduled readouts plus significant changes should be telemetered to the FWO.

3. An upper air network with a station spacing of 60 to 90 n.m. and a capability of making observations as frequently as once an hour is also required.

4. For the purposes of this plan, mesoscale systems are defined as those systems whose average dimensions are: length 60 n.m., speed 30 kt, and duration 2 hours. Such a system sweeps an area of 3,600 square n.m. in that time. A typical example of these systems is the instability line (squall line). They encompass the following meteorological phenomena:

a. Meso-highs and meso-lows - Characteristic meteorological parameters of these systems have been identified. There appears to be a multiplicity of highs and lows that make up the conventional portrayal of highs and lows that are characteristic of macroscale systems.

b. Pressure change lines - These pressure rise and wake depression lines analyzed on the mesoscale usually consist of a multiplicity of pressure rise and pressure fall lines. Many of the lines are trivial, but the importance of detecting the lines has been demonstrated by the fact that at least some of them can grow into intense squall lines.

c. Temperature and humidity changes - The changes associated with squall lines, precipitation areas, and other phenomena are not detailed by the conventional macroscale analysis. A substantial temperature rise following the passage of nocturnal thunderstorms appears to be quite common along with an associated marked humidity fall. These indications of the internal processes of thunderstorms are significant, for example, in determining the decay of a squall line system.

d. Wind - There are significant mesoscale variations in wind that cannot be detected from existing networks. In particular, winds of damaging speed are frequently missed by the existing synoptic network. Derived kinematic properties, such as divergence and vorticity, could be computed with meaningful results with good wind data from a mesoscale network.

e. Precipitation - Significant mesoscale features of precipitation usually exist that are not detectable in a synoptic network. Locally heavy rains, which may result in flash flooding, can be observed in detailed mesonetworks.

5. The design and operation of the observation network should be based on the following criteria suggested in OFCM Report 67-2:

a. The data acquisition programs should be planned to the extent possible around existing facilities.

b. When feasible, the additional equipment required to implement the full programs should be movable to permit its utilization in a succession of representative sites.

c. The field program should be planned to acquire the necessary data simultaneously for more than one project.

d. The data required at different sites and for different purposes should be compatible.

e. The measurements of the principal meteorological elements (pressure, wind, temperature, and moisture) are required for the solution of all mesoscale problems.

f. Certain auxiliary measurements are essential for particular problems under study.

g. Real-time data acquisition is desirable in many research projects to permit a continuing data system evaluation and a simultaneous operational use of these data at small additional costs.

h. In line with current NOAA policies, all data-related information and original project records must be filed in optimum computer compatible form at the National Weather Records Center.

6. It is of major importance that in addition to the surface and upper air coverage and spacing requirements, the network area be under the surveillance of WSR-57 radars. Also 1/2-mile resolution geostationary satellite imagery is essential at intervals not to exceed 1 hour; the capability must be developed to obtain observations of selected areas at more frequent intervals.

D. Phasing

The Operational Field Test Program will be initiated in two phases:

Phase 1. The OFTF will be established under the direction and control of the appropriate NWS Regional Director. The FWO and the experimental observation network should be established simultaneously with initial attempts to improve the 0- to 6-hour forecast started as soon as communications and network data are available. Organization of the forecast improvement effort is not to await newly developed guidance material, automated data handling, and display or special configuration of satellite and radar data presentations. Modifications and supplements to the network should be made as experience with the observation network is gained and more detailed requirements for data result from the development of forecast and nowcast techniques and procedures. Basically this is the phase of installation, development, and modification of the OFTF.

Phase 2. In this phase, the FWO is expanded and will simulate complete WSFO operations including the preparation of all required products under usual deadlines. The observing network will be expanded as appropriate with respect to conventional observation techniques, and increased use will be made of remote-sensing techniques. The network will be brought up to a high level of activity for a 90-day concentrated data collection period in support of specialized data-gathering projects (e.g., boundary layer, clouds, and precipitation, air resources, and several convective storms), after which time it may or may not continue at that level depending on the need for data density and frequency of that order. It is at this time that NOAA elements and other Federal agencies would be invited to use the OFTF for special experiments, and the basic observation network would be augmented temporarily to meet their needs on a reimbursable basis.

ATTACHMENT D

Allocation of Resources

This attachment is a summary of the estimated costs of this plan. It is organized along major areas of effort and actions to be taken to establish and maintain the Operational Field Test Facility and to initiate supporting scientific programs. The program costs are identified in five phases.

Pages 32 to 35 summarize the costs for the five phases, and the rest of the attachment provides the initial implementation costs of Phase 1 and back-up details for Phases 1 and 2. Because of the lead time required, Phase 1 cannot be implemented before the last quarter of the fiscal year for which funds become available. Phase 1 costs for certain items are figured on this basis, with the full annualized cost of the items shown in the following Phase 2.

Resources Required

(In thousands of dollars and additive except for FEC)

Item	Approp.	Phase 1 Pos.	Phase 1 Costs $K	Phase 2 Pos.	Phase 2 Costs $K	Phase 3 Pos.	Phase 3 Costs $K	Phase 4 Pos.	Phase 4 Costs $K	Phase 5 Pos.	Phase 5 Costs $K
1. Operational Field Test Facility											
a. Facility Weather Office	S&E	25	148	0	275	0	0	0	0	0	0
	FEC	0	230	0	0	0	0	0	0	0	0
b. Experimental observation network	S&E	0	262	0	320	0	0	0	0	0	0
	FEC	0	800	0	300	0	0	0	0	0	0
2. Mesoscale Observation Measurements											
a. GOES imagery staff and equipment	R&D	1	30	0	0	0	0	0	0	0	0
	FEC	0	65	0	0	0	0	0	0	0	0
b. Radar digital data terminal equipment	R&D	0	25	0	(-)25	0	0	0	0	0	0
c. Radar/satellite mosaic terminal equip.	R&D	0	12	0	0	0	(-)12	0	0	0	0
d. Video imagery playback terminal equip.	R&D	0	12	0	(-)12	0	0	0	0	0	0
e. Remote station development	R&D	3	100	0	0	0	0	0	0	0	0

Resources Required--Continued

(In thousands of dollars and additive except for FEC)

Item	Approp.	Phase 1		Phase 2		Phase 3		Phase 4		Phase 5	
		Pos.	Costs $K	Pos.	Costs $K	Pos.	Costs $K	Pos.	Costs $K	Pos.	Costs $K
f. AMOS augmentation modules	R&D	1	100	0	0	0	0	(-)1	(-)100	0	0
	FEC	0	75	0	425	0	0	0	0	0	0
g. FLUX measurement system	R&D	0	0	0	1,000	0	0	0	0	0	0
	FEC	0	1,300	0	200	0	0	0	0	0	0
h. Remote-sensing equipment	R&D	4	175	0	0	0	100	0	(-)100	0	(-)175
	FEC	0	125	0	375	0	0	0	0	0	0
i. Low-cost automatic stations	R&D	0	0	2	100	1	150	0	0	0	0
	FEC	0	0	0	0	0	100	0	0	0	0
3. Research on Mesoscale Phenomena											
a. Measurement and modeling of tornadoes & severe storms	R&D	2	200	0	0	0	0	0	0	0	0
b. Doppler radar techniques	R&D	4	160	0	0	(-)4	(-)160	0	0	0	0
c. Airborne Doppler radar	R&D	0	100	0	0	0	(-)100	0	0	0	0
d. Computer adaptation to mesoscale	R&D	4	800	(-)2	(-)400	0	0	0	0	0	0
e. Mesoscale interaction with general circulation (univ. grants)	R&D	0	0	0	250	0	0	0	0	0	0

Resources Required--Continued

(In thousands of dollars and additive except for FEC)

Item	Approp.	Phase 1		Phase 2		Phase 3		Phase 4		Phase 5	
		Pos.	Costs $K	Pos.	Costs $K	Pos.	Costs $K	Pos.	Costs $K	Pos.	Costs $K
4. Forecasting Technique Development											
a. Modeling for severe storms	R&D	6	300	0	0	0	0	0	0	0	0
b. 0- to 6- hr forecast guidance material	R&D	0	0	1	100	0	0	0	0	0	0
5. Forecast Office Operational Procedure											
a. Equipment & tasks automation	R&D	1	50	0	100	0	0	0	0	0	0
b. WSFO/WSO communication	S&E	0	0	0	75	0	0	0	0	0	0
6. General Public & User Group Service Procedures											
a. Metropolitan area automatic phones	S&E	0	0	0	0	0	390	0	500	0	1,000
	R&D	0	0	1	40	0	0	0	0	0	0
b. Video transmissions of radar/satellite imagery	R&D	0	0	1	50	0	0	0	0	0	0
7. Training											
a. Graduate & post graduate training in mesoscale forecasting	S&E	25	375	25	375	50	750	0	0	0	0

Resources Required--Continued

(In thousands of dollars and additive except for FEC)

Item	Approp.	Phase 1		Phase 2		Phase 3		Phase 4		Phase 5	
		Pos.	Costs $K	Pos.	Costs $K	Pos.	Costs $K	Pos.	Costs $K	Pos.	Costs $K
8. Support to Specialized Projects											
a. Modeling on the mesoscale	R&D	2	75	8	200	0	700	(-)4	(-)725	(-)6	(-)275
	FEC	0	0	0	375	0	0	0	0	0	0
TOTALS	S&E	50	785	25	1,045	50	1,140	0	500	0	1,000
	R&D	28	2,139	11	1,403	(-)3	678	(-)5	(-)925	(-)6	(-)450
	FEC	0	2,595	0	1,675	0	100	0	0	0	0

(General Note: S&E - Salaries and Expenses; R&D - Research and Development; and FEC - Facilities, Equipment, and Construction; and $K - in thousands of dollars.)

Initial Implementation Costs -- Phase I

Line Item	S&E		R&D		FEC	
	Pos.	Costs $K	Pos.	Costs $K	Pos.	Costs $K
1. Operational Field Test Facility	25	410	0	0	0	1,030
2. Mesoscale Observations and Measurements	0	0	9	454	0	1,565
3. Research on Mesoscale Phenomena	0	0	10	1,260	0	0
4. Forecasting Technique Development	0	0	6	300	0	0
5. Forecast Office Operational Procedure	0	0	1	50	0	0
6. Public and User Groups Service Procedure	(Significant costs do not start until Phase 2)					
7. Training	25	375	0	0	0	0
8. Support to Specialized Projects	0	0	2	75	0	0
Phase I Totals	50	785	28	2,139	0	2,595

Note: S&E - Salaries and Expenses; R&D - Research and Development; FEC - Facilities, Equipment, and Construction; and $K - in thousands of dollars.)

1. Operational Field Test Facility (OFTF)

Phase 1: (25 positions, $410,000 S&E); ($1,030,000 FEC)
Phase 2: (25 positions, $1,005,000 S&E); ($300,000 FEC)

a. 25 positions and $148,000 S&E and $230,000 FEC funds in Phase 1 will establish the FWO and operate it for the last 4 months of the fiscal year. This cost includes rent, furniture, internal instrumentation, and contingency. The FWO is the management element of the OFTF and will test and evaluate, and in some cases develop, weather observation and measurement systems, 0- to 6- hour local forecasting techniques, and services to user groups. The Facility will also provide a test bed for scientific research and development.

25 positions and $423,000 S&E funds will be the full annualization of this item for Phase 2. The above Phase 1 FEC cost is for one-time purchase of furniture and instrumentation.

b. $262,000 S&E and $800,000 FEC funds in Phase 1 will equip and operate the experimental observation network for the last 4 months of the fiscal year. As an integral part of the OFTF, the network will be specifically designed to provide data on the mesoscale to the FWO. Initially it will include 16 AMOS III-70 automatic meteorological observing stations, upper air soundings, and radar coverage. This basic network will be augmented by remote-sensing equipment for horizontal and vertical profiles on the mesoscale and profiles of momentum and heat flux.

$582,000 S&E and $300,000 FEC will be the full annualization cost of this item for Phase 2. This includes capital cost of one additional upper air station and its operation for an entire year plus expendable for increased observations for three existing stations.

2. Mesoscale Observations and Measurements

Phase 1: (9 positions, $454,000 R&D); ($1,565,000 FEC)
Phase 2: (11 positions, $1,517,000 R&D); ($1,000,000 FEC)

a. 1 position and $30,000 R&D and $65,000 FEC in Phase 1 will provide the FWO with the staff, terminal equipment, and display for Geostationary Satellite Imagery. This will enable the use of real-time cloud imagery from ATS and GOES satellites to enhance the weather watch capabilities for forecasting and to provide qualitative information on the growth, movement, and dissipation of small-scale systems. It is planned that a Type "B" terminal be established with the display device of the direct or dry process type and that film loops will not be required. Since no suitable device is now available, R&D will be needed to complete development of the required high-resolution display.

The 1 position and $30,000 R&D also for Phase 2 will enable continued development and modification of equipment and applications.

b. $25,000 R&D in Phase 1 will provide the FWO with the terminal equipment and display for weather radar digital data. The objective is to automate the manual interpretation and summarization now done at the local radar station and composited by the Radar Analysis and Development Unit at Kansas City. This approach will provide automatic and rapid communication, compositing, and objective utilization of radar information along with other types of data at forecast and warning units. As now planned, OFTF will not be one of the reporting radars in the digitization system network. All that is required is a terminal readout or display of the digitized radar data from the immediate area. No funding is anticipated after the first year.

c. $12,000 R&D in Phase 1 will provide terminal readout equipment that FWO needs to receive the mosaics of weather radar data from the digitization network and the ATS and GOES satellite imagery for use in establishing the initial cloud state on a qualified basis. Since the system is not yet operational, some R&D on the terminal readout and display will be needed as well as the equipment purchase.

$12,000 R&D will also be needed in Phase 2 before the installation can be made operational.

d. $12,000 R&D in Phase 1 will purchase the terminal equipment for video recording of radar and satellite imagery to provide the meteorologist with a playback of the imagery so that the small-scale motion systems can be detected and studied in a meaningful manner. No funding past the first year is anticipated.

e. 3 positions and $100,000 R&D in Phase 1 will be used to accelerate the development of an automated surface-observing system utilizing remote automatic weather-reporting stations. A vigorous development program is required to develop the sensors and associated electronics that are accurate, reliable, and rugged enough to survive climatic extremes such as freezing rain and to report weather measurements from remote, uninhabited areas.

Continuing the 3 positions and $100,000 R&D funds in Phase 2 and succeeding phases will enable further development, procurement, and testing of prototype equipment.

f. 1 position and $100,000 R&D and $75,000 FEC in Phase 1 will be used to develop "add on" modules to the AMOS III-70 surface system in the experimental observation network to measure solar radiation, net radiation, precision pressure, and vector winds over short averaging times. Also, data logging and transmission systems compatible with communication and computer facilities will be designed. This Phase 1 funding will allow study and development of necessary sensors and interface hardware and procurement of prototypes.

1 position and $100,000 R&D and $425,000 FEC in Phase 2 will provide for the construction and/or procurement of radiation, wind, and pressure sensors and data loggers for installation on the 16 AMOS III-70 system.

g. $1,300,000 FEC in Phase 1 will provide for equipment procurement of long lead-time items for the Flux Measurement Systems of the OFTF. This will include a balloon-borne turbulent flux measurement system with sensors, telemetry system, and balloon and handling system. Also, a precision rawinsonde system of the LORAN C/OMEGA type or equal will be procured, including 16 ground units and the preliminary order for test and evaluation of both sondes and ground system.

$1,000,000 R&D and $200,000 FEC in Phase 2 will procure the field supplies and expendables, i.e., inflation shelters, inflation gas, balloons, sondes, and charts.

h. 4 positions and $175,000 R&D and $125,000 FEC will accelerate the development of transportable vertical profile systems for measurement of winds and general thermal structure (acoustic radar) and humidity (Raman scattering). It will allow test and evaluation of these systems in an experimental environment. Also, airborne radiometer systems will be tested for below-aircraft temperature profiles vs. tower-mounded profiles. Tests will be made of airborne, real-time Doppler-determined winds vs. tower profiles.

4 positions and $175,000 R&D and $375,000 FEC in Phase 2 will provide for continued test and evaluation plus the construction and employment of two additional profile systems.

i. 2 positions and $100,000 R&D in Phase 2 will provide for the development, procurement, and testing of a prototype low-cost automatic observing station. Emphasis on mesoscale forecasting requires mesoscale observations that supplement the basic surface observation network. The available AMOS III-70 system is designed for use at either manned locations and/or at sites where AC power and teletypewriter communications are available. A lower cost station is needed for use at the many "gap filler" observing points.

3. Research on Mesoscale Phenomena

Phase 1: (10 positions, $1,260,000 R&D)
Phase 2: (8 positions, $1,110,000 R&D)

a. 2 positions and $200,000 R&D in Phase 1 will be used to improve prediction and warning of dangerous severe storms through the use of enhanced field measurements and computer modeling. Previous research has led to the ability to measure the physical processes involved and to analyze effectively the storm data obtained. The processes of condensation and precipitation and their interaction with the horizontal and vertical wind fields in tornadoes and other severe storms are extremely complicated, but the physical-mathematical models under development now hold promise of a closer match to the actual processes of the storms. Recent work has for the first time simulated vortex families in association with storm downdrafts, and progress has been made in modeling rainfall processes involving moisture and thermal structure as associated with the systematic strong updrafts needed to produce tornadoes.

2 positions and $200,000 R&D are needed in Phase 2 to continue the model development and for adaptation to operational techniques of the FWO.

b. 4 positions and $160,000 R&D in Phase 1 will complete a network of three highly sophisticated Doppler radars assisted by on-line computers for the processing and display of storm particle velocity information. The present limited understanding of severe storm and tornado behavior and intensity is primarily the result of the lack of observational data on severe winds and turbulence within storms and their environment. Doppler radar techniques are capable of providing the much needed wind and turbulence information in any storm which is in the area covered by the radar system. However, the development of the method as a practical tool for probing severe storms heavily relies on the development of a network of Doppler radars assisted by computers capable of processing the radar information in real time. This research will for the first time provide a clear understanding of the three-dimensional structure of the wind and turbulence inside storm systems, as well as a knowledge of the optimum techniques involved in the establishment of a nationwide network for severe storm detection and monitoring. This research has important public benefits extending from severe storm warnings to forecasting the severity of storm systems as related to air traffic safety.

4 positions and $160,000 R&D will be needed through Phase 2.

c. $100,000 R&D in Phase 1 will provide for development of an airborne Doppler radar system to extend the atmospheric research capabilities of airplanes to the sensing of particle velocities inside storms and thereby provide an important new means for the monitoring of storm dynamics. The system is to be installed aboard one of the airplanes operated by the Research Flight Facility of NOAA. The application of the system will include observing the structure of vertical air motion and particle size within hurricanes and the probing of vertical air motions in convective storms in tropical regions. Approximately 75 percent of this increase is for hardware components and 25 percent for salaries and materials for design and assembly of the total system in the aircraft.

$100,000 R&D will be needed through Phase 2.

d. 4 positions and $800,000 R&D in Phase 1 will initiate the development of three-dimensional models of atmospheric flow including the interactions between the earth and atmosphere. This encompasses radiation, cloudiness, diabatic effects, and surface characteristics. These funds will be used for in-house GFDL model and computer adaptation and for contracts for independent approaches to mesoscale modeling.

2 positions and $400,000 R&D will be needed in Phase 2 to continue the model development and adaptation and to begin field test application.

e. $250,000 R&D in Phase 2 will be used for grants and contracts to:

1) Develop a syllabus for mesometeorological training;

2) Stimulate academic interest in mesometeorological research;

3) Gain further understanding of mesoscale motions and their interrelation with the general circulation; and,

4) Develop and maintain a balanced effort between the solution of pressing operational problems and emphasis upon longer range and fundamental problems.

4. Forecasting Technique Development

Phase 1: (6 positions, $300,000 R&D)
Phase 2: (7 positions, $400,000 R&D)

a. 6 positions and $300,000 in Phase 1 are required for the development of numerical analysis and prediction models of the atmosphere, the details of which match the detail from the new observing instruments, such as those aboard weather satellites. Observing and predicting scales of motion of the order of several kilometers will provide guidance materials for forecasters to use in issuing improved mesoscale short-range forecasts (those dealing with space and time scales associated with severe convective-type storms, severe winter storms, air pollution potential forecasting, and precipitation forecasting). These funds will provide for the development of enhanced vertical detail in our operational models of the atmosphere and the development of optimum methods of incorporating the new satellite radiation data into the analysis and prediction systems. Such data differ from the conventional data, which are valid at several particular observing stations. The new data, on the other hand, will be valid at many times of the day and concentrated at locations in the vicinity of the paths of the satellites. The prediction method must incorporate new and improved techniques of accounting for atmosphere-earth boundary fluxes of momentum, heat, and moisture--important sources and sinks of atmospheric energy. Experiments with such models, containing proper treatment of the physical processes prevalent in the atmospheric boundary layer, will also provide for better forecasting of severe storms and air pollution potential.

b. 1 position and $100,000 R&D in Phase 2 will provide for the development of new centrally prepared guidance material from NMC and other centers for tailored use by the FWO. This will include not only facsimile chart transmission but also automated data and chart selection and transmission and real-time on-request-type support and coordination on the 0- to 6-hour forecast problem.

5. Forecast Office Operational Procedure

Phase 1: (1 position, $50,000 R&D)
Phase 2: ($75,000 S&E; 1 position, $150,000 R&D)

a. 1 position and $50,000 R&D funds in Phase 1 will accelerate the development of automated equipment systems to improve the effectiveness of field station operations. This research and development program is required to introduce systematically modern technology in both communications and data processing and display into the day-to-day operations in the field. This effort addresses problems of technological assessment and adaptation and focuses on maximizing the utilization of scarce, skilled manpower by automating routine, repetitive tasks. Although the field station operations are often thought of only in terms of the major functions of observing and forecasting, a great deal of other necessary activity goes on. Incoming information/data in various forms and formats must be handled, organized, displayed, and processed. Outgoing messages must be composed, edited, and disseminated, again in a variety of forms and formats. All this consumes a great deal of manpower, often at the expense of the primary functions of preparing forecasts and warnings. Field operations must be modernized if current services are to improve without large increases in staff.

1 position and $150,000 R&D in Phase 2 will be used to complete development of computerized tasks, formats, and displays. Field testing of terminal equipment and operation procedure can be completed at the Facility Weather Office.

b. $75,000 S&E in Phase 2 will implement in the remainder of the NWS Regions, the "Red Phone" capability between WSFOs, and associated WSOs that exist in the NWS Eastern Region.

6. General Public and User Groups Service Procedures

Phase 2: (2 positions, $90,000 R&D)

a. 1 position and $40,000 R&D in Phase 2 will start development and prototype test of a dial-a-forecast service designed ultimately for the 100 most populous Standard Metropolitan Statistical Areas in the country. In addition to the standard automatic-telephone-type service for general public weather information, special dial-up service would be available for travelers, campers, boaters, winter sportsmen, fishermen, and other outdoor enthusiasts as required seasonally for the metropolitan area served. This user-oriented service would be phased in at the rate of about 25 areas/year starting in Phase 3.

b. 1 position and $50,000 R&D in Phase 2 will develop the prototype system of direct video transmissions over local commercial television stations of satellite and radar imagery from WSFO and/or WSOs. This system will be part of the local forecast and nowcast service provided the general public.

7. Training

Phase 1: (25 positions and $375,000 S&E)
Phase 2: (50 positions and $750,000 S&E)

25 positions and $375,000 S&E in Phase 1 will provide training at the university level in schools featuring short-range forecasting techniques

and training. Present curricula of the academic community places little emphasis on meteorological training designed to produce an adequate forecast in the 0- to 6-hour time frame. Most forecasters with this skill have developed and learned only through experience over a significant period of time with little formal training in mesoscale forecasting. By the mid 1970's, most forecast offices are expected to have access to near-continuous satellite imagery and considerably improved radar displays and mosaics. This will permit the forecaster to study time-lapse movies of cloud changes in his area of interest. However, proper interpretation of such imagery requires adequate knowledge of the dynamic and thermodynamic processes involved in the varying scales of motion. While some success will no doubt be enjoyed initially through existing experience, training must be provided to assure that those persons assigned the responsibility for interpreting the imagery are well grounded in mesometeorology. With these funds the required university syllabus will be developed and 100 university scholarships provided.

50 positions and $750,000 S&E in Phase 2 will expand this undergraduate and graduate training to meet the continuing demand for mesometeorologists.

8. Support to Specialized Projects

Phase 1: (2 positions, $75,000 R&D)
Phase 2: (10 positions, $275,000 R&D; $375,000 FEC)

2 positions and $75,000 R&D in Phase 1 will initiate the observational logistics and network systems study in support of the special project of modeling for the mesoscale. These funds will establish the Project Office to finalize goals and operational design criteria. Quantitative analysis of installation costs, real estate needs, installation preparation communications, and office and observational space requirements will also be determined.

10 positions, $275,000 R&D and $375,000 FEC in Phase 2 will execute the network logistics and installation. The entire system will be checked out and tests made in preparation for conducting the extension field study during Phase 3.

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